

1 **CLAIMS**

2 1. A method for image retrieval using a statistical bigram correlation model,
3 the method comprising:

4 receiving a plurality of images responsive to multiple search sessions;

5 determining whether the images are semantically relevant images via
6 relevance feedback; and

7 estimating a respective semantic correlation between each of at least one
8 pair of the images with a respective bigram frequency, each respective bigram
9 frequency being based on multiple search sessions in which each image of the pair
10 is indicated to be a semantically relevant image.

12 2. A method as recited in claim 1, further comprising:

13 assigning a respective ranking score to each of the images based at least in
14 part on the respective semantic correlation corresponding to the image; and

15 displaying only those images with a highest range of ranking scores.

17 3. A method as recited in claim 1, further comprising, responsive to a search
18 session, dynamically updating the respective bigram frequency corresponding to
19 two of the images.

21 4. A method as recited in claim 1, wherein the respective semantic correlation
22 is: (a) a positive correlation between two semantically relevant images; (b) a
23 negative correlation between a semantically relevant image and a semantically
24 irrelevant image; and (c) no correlation otherwise.

1 **5.** A method as recited in claim 1:

2 wherein the respective semantic correlation is performed offline or online
3 to calculate unigram and bigram frequencies from relevance feedback information,
4 the unigram frequency being based on relevance feedback to a session of the
5 multiple search sessions, the unigram frequency indicating that each respective
6 image of the images is either semantically relevant to the session, semantically
7 less relevant to the session, or a non-feedback image with respect to the session;
8 and

9 wherein each respective bigram frequency is based on a pair of unigram
10 frequencies.

11
12 **6.** A method as recited in claim 1, wherein estimating the respective semantic
13 correlation further comprises:

14 associating a respective unigram frequency with each of the images, the
15 unigram frequency indicating that each respective image of the images is either
16 semantically relevant, semantically less relevant, or a non-feedback image, the
17 unigram frequency being based on relevance feedback to a session of the multiple
18 search sessions; and

19 wherein each respective bigram frequency is based on a pair of unigram
20 frequencies.

1 7. A method as recited in claim 1, wherein estimating the respective semantic
2 correlation further comprises:

3 associating a respective unigram frequency with each of the images, the
4 unigram frequency indicating that each respective image of the images is either
5 semantically relevant, semantically less relevant, or a non-feedback image, the
6 unigram frequency being based on relevance feedback to a session of the multiple
7 search sessions;

8 determining a maximum frequency from a maximum value of the bigram
9 and unigram frequencies; and

10 wherein the respective semantic correlation is further based on the
11 maximum frequency.

12
13 8. A method as recited in claim 1, further comprising identifying, for each
14 image obtained responsive to one or more search sessions of the multiple search
15 sessions, a respective semantic support based on a similarity measure and/or the
16 respective semantic correlation, the similarity measure corresponding to a
17 similarity of a respective feature vector of the image and a search query
18 corresponding to the session.

1 9. A method as recited in claim 1, further comprising:

2 identifying, for each image obtained responsive to one or more search
3 sessions of the multiple search sessions, a respective semantic support based on a
4 similarity measure and/or the respective semantic correlation, the similarity
5 measure corresponding to a similarity of a respective feature vector of the image
6 and a search query corresponding to the session;

7 assigning a respective ranking score to each of the images based upon the
8 respective similarity measure, the respective semantic support, and a semantic
9 weight; and

10 displaying only those images with a highest range of respective ranking
11 scores.

12

13 10. A method as recited in claim 1, wherein estimating the respective semantic
14 correlation is determined as follows:

- 15 • $0 \leq R(I, J) \leq 1$ [if is true in all cases]
- 16 • $R(I, J) = R(J, I)$; [if is true in all cases]
- 17 • if $I=J$ and $U(I) \leq 0$: $R(I, J) = 0$;
- 18 • if $I \neq J$ and $B(I, J) \leq 0$: $R(I, J) = 0$;
- 19 • if $I=J$ and $U(I) > 0$: $R(I, J)=U(I)/T$; or
- 20 • if $I \neq J$ and $B(I, J) > 0$: $R(I, J)=B(I)/T$;

21 wherein I, J are two images, $B(I, J)$ is their bigram frequency, $U(I)$ is the
22 unigram frequency of image I , T is the maximum frequency, $R(I, J)$ is the
23 correlation between image I and J.

1 11. A method as recited in claim 1, wherein each respective bigram frequency
2 is based on a pair of unigram frequencies, and wherein the method further
3 comprises performing the respective semantic correlation offline by:

- 4 (a) initializing all unigram and bigram frequencies to zero;
5 (b) clustering search sessions with a same query into groups;
6 (c) calculating unigram counts within a group;
7 (d) updating unigram frequencies ;
8 (e) updating bigram frequencies;
9 (f) repeating operations (c), (d), and (f) for all session groups;
10 (g) setting all negative unigram and bigram frequencies to zero; and
11 (h) calculating each respective semantic correlation based on results of (a)
12 through (f).

1 12. A method as recited in claim 1, wherein each respective bigram frequency
2 is based on a pair of unigram frequencies, wherein $C(I)$ is a unigram count of
3 image I , and wherein the method further comprises performing the respective
4 semantic correlation offline by:

5 (a) initializing $C(I)$ to zero (0);

6 (b) iteratively updating $C(I)$ for every session in a group such that:

7 $C(I) = C(I) + 1$, if image I is labeled as relevant in a session;

8 $C(I) = C(I) - 1$, if image I is labeled as irrelevant in a session; and

9 $C(I)$ is unchanged otherwise.

10 (c) repeating (b) for every image of the images;

11 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;

12 (e) updating each respective bigram frequency of an image pair such that:

13 $B(I, J) = B(I, J) + \min\{C(I), C(J)\}$, if $C(I) > 0, C(J) > 0$,

14 $B(I, J) = B(I, J) - \min\{C(I), -C(J)\}$, if $C(I) > 0, C(J) < 0$,

15 $B(I, J) = B(I, J) - \min\{-C(I), C(J)\}$, if $C(I) < 0, C(J) > 0$, and

16 $B(I, J) = B(I, J)$, otherwise; and

17 wherein I, J are two images, $B(I, J)$ is their bigram frequency, and

18 $U(I)$ is the unigram frequency of image I .

1 **13.** A method as recited in claim 1, wherein each respective bigram frequency
2 is based on a pair of unigram frequencies, and wherein the method further
3 comprises performing the respective semantic correlation online by:

- 4 (a) calculating unigram counts in a particular search session;
5 (b) updating unigram frequencies;
6 (c) updating bigram frequencies; and
7 (d) updating each respective semantic correlation between each of the
8 images based on results of (a) through (c).

1 14. A method as recited in claim 1, wherein each respective bigram frequency
2 is based on a pair of unigram frequencies, wherein $C(I)$ is a unigram count of
3 image I , wherein $U(I)$ is a unigram frequency of image I , wherein $B(I,J)$ is a
4 bigram frequency of image I and J , wherein a session group comprises a single
5 search session, and wherein the method further comprises performing the
6 respective semantic correlation online by:

7 (a) responsive to determining that there is a user log, updating calculating
8 each respective unigram and bigram frequency according to data in the user log;

9 (b) responsive to determining that there is not a user log, initializing each
10 $C(I)$ and $B(I)$ to zero (0);

11 (c) iteratively updating $C(I)$ for the single search session such that:

12 $C(I) = 1$, if image I is labeled as relevant;

13 $C(I) = -1$, if image I is labeled as irrelevant; and

14 $C(I) = 0$, if $C(I)$ is a non-feedback image;

15 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;

16 (e) updating each respective bigram frequency of an image pair such that:

17 $B(I,J) = B(I,J) + 1$, if $C(I) > 0, C(J) > 0$,

18 $B(I,J) = B(I,J) - 1$, if $C(I) > 0, C(J) < 0$,

19 $B(I,J) = B(I,J) - 1$, if $C(I) < 0, C(J) > 0$, or

20 $B(I,J) = B(I,J)$, otherwise; and

21 wherein I, J are two images, and $B(I,J)$ is their bigram frequency.

1 **15.** A computer-readable medium for image retrieval using a statistical bigram
2 correlation model, the computer-readable medium comprising computer-
3 executable instructions for:

4 receiving a plurality of images responsive to multiple search sessions;

5 determining whether the images are semantically relevant images via
6 relevance feedback; and

7 estimating a respective semantic correlation between each of at least one
8 pair of the images with a respective bigram frequency, each respective bigram
9 frequency representing a probability of whether two of the images are
10 semantically related to one-another based on a co-occurrence frequency that each
11 image of the two images was relevant in a previous query/feedback session.

12
13 **16.** A computer-readable medium as recited in claim 15, further comprising
14 instructions for:

15 assigning a respective ranking score to each of the images based at least in
16 part on the respective semantic correlation corresponding to the image; and

17 displaying only those images with a highest range of ranking scores.

18
19 **17.** A computer-readable medium as recited in claim 15, further comprising
20 instructions for, responsive to a search session, dynamically updating the
21 respective bigram frequency corresponding to two of the images.

1 **18.** A computer-readable medium as recited in claim 15, wherein the respective
2 semantic correlation is: (a) a positive correlation between two semantically
3 relevant images; (b) a negative correlation between a semantically relevant image
4 and a semantically irrelevant image; and (c) no correlation otherwise.

5

6 **19.** A computer-readable medium as recited in claim 15:

7 wherein the respective semantic correlation is performed offline or online
8 to calculate unigram and bigram frequencies from relevance feedback information,
9 the unigram frequency being based on relevance feedback to a session of the
10 multiple search sessions, the unigram frequency indicating that each respective
11 image of the images is either semantically relevant to the session, semantically
12 less relevant to the session, or a non-feedback image with respect to the session;
13 and

14 wherein each respective bigram frequency is based on a pair of unigram
15 frequencies.

16

17 **20.** A computer-readable medium as recited in claim 15, wherein estimating
18 the respective semantic correlation further comprises instructions for:

19 associating a respective unigram frequency with each of the images, the
20 unigram frequency indicating that each respective image of the images is either
21 semantically relevant, semantically less relevant, or a non-feedback image, the
22 unigram frequency being based on relevance feedback to a session of the multiple
23 search sessions; and

24 wherein each respective bigram frequency is based on a pair of unigram
25 frequencies.

1
2 **21.** A computer-readable medium as recited in claim 15, wherein estimating
3 the respective semantic correlation further comprises instructions for:

4 associating a respective unigram frequency with each of the images, the
5 unigram frequency indicating that each respective image of the images is either
6 semantically relevant, semantically less relevant, or a non-feedback image, the
7 unigram frequency being based on relevance feedback to a session of the multiple
8 search sessions;

9 determining a maximum frequency from a maximum value of the bigram
10 and unigram frequencies; and

11 wherein the respective semantic correlation is further based on the
12 maximum frequency.

13
14 **22.** A computer-readable medium as recited in claim 15, further comprising
15 instructions for identifying, for each image obtained responsive to one or more
16 search sessions of the multiple search sessions, a respective semantic support
17 based on a similarity measure and/or the respective semantic correlation, the
18 similarity measure corresponding to a similarity of a respective feature vector of
19 the image and a search query corresponding to the session.

1 **23.** A computer-readable medium as recited in claim 15, further comprising
2 instructions for:

3 identifying, for each image obtained responsive to one or more search
4 sessions of the multiple search sessions, a respective semantic support based on a
5 similarity measure and/or the respective semantic correlation, the similarity
6 measure corresponding to a similarity of a respective feature vector of the image
7 and a search query corresponding to the session;

8 assigning a respective ranking score to each of the images based upon the
9 respective similarity measure, the respective semantic support, and a semantic
10 weight; and

11 displaying only those images with a highest range of respective ranking
12 scores.

13
14 **24.** A computer-readable medium as recited in claim 15, wherein estimating
15 the respective semantic correlation is determined as follows:

- 16 • $0 \leq R(I, J) \leq 1$
- 17 • $R(I, J) = R(J, I)$;
- 18 • if $I=J$ and $U(I) \leq 0$: $R(I, J) = 0$;
- 19 • if $I \neq J$ and $B(I, J) \leq 0$: $R(I, J) = 0$;
- 20 • if $I=J$ and $U(I) > 0$: $R(I, J)=U(I)/T$; or
- 21 • if $I \neq J$ and $B(I, J) > 0$: $R(I, J)=B(I)/T$;

22 wherein I, J are two images, $B(I, J)$ is their bigram frequency, $U(I)$ is the
23 unigram frequency of image I , T is the maximum frequency, $R(I, J)$ is the
24 correlation between image I and J.

1 **25.** A computer-readable medium as recited in claim 15, wherein each
2 respective bigram frequency is based on a pair of unigram frequencies, and
3 wherein the computer-executable instructions further comprise instructions for
4 performing the respective semantic correlation offline by:

- 5 (a) initializing all unigram and bigram frequencies to zero;
6 (b) clustering search sessions with a same query into groups;
7 (c) calculating unigram counts within a group;
8 (d) updating unigram frequencies ;
9 (e) updating bigram frequencies;
10 (f) repeating operations (c), (d), and (f) for all session groups;
11 (g) setting all negative unigram and bigram frequencies to zero; and
12 (h) calculating each respective semantic correlation based on results of (a)
13 through (f).

1 **26.** A computer-readable medium as recited in claim 15, wherein each
2 respective bigram frequency is based on a pair of unigram frequencies, wherein
3 $C(I)$ is a unigram count of image I , and wherein the computer-executable
4 instructions further comprise instructions for performing the respective semantic
5 correlation offline by:

6 (a) initializing $C(I)$ to zero (0);

7 (b) iteratively updating $C(I)$ for every session in a group such that:

8 $C(I) = C(I) + 1$, if image I is labeled as relevant in a session;

9 $C(I) = C(I) - 1$, if image I is labeled as irrelevant in a session; and

10 $C(I)$ is unchanged otherwise;

11 (c) repeating (b) for every image of the images;

12 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;

13 (e) updating each respective bigram frequency of an image pair such that:

14 $B(I,J) = B(I,J) + \min\{C(I),C(J)\}$, if $C(I) > 0, C(J) > 0$,

15 $B(I,J) = B(I,J) - \min\{C(I),-C(J)\}$, if $C(I) > 0, C(J) < 0$,

16 $B(I,J) = B(I,J) - \min\{-C(I),C(J)\}$, if $C(I) < 0, C(J) > 0$, and

17 $B(I,J) = B(I,J)$, otherwise; and

18 wherein I, J are two images, $B(I,J)$ is their bigram frequency, and

19 $U(I)$ is the unigram frequency of image I .

1 **27.** A computer-readable medium as recited in claim 15, wherein each
2 respective bigram frequency is based on a pair of unigram frequencies, and
3 wherein the computer-executable instructions further comprise instructions for
4 performing the respective semantic correlation online by:

- 5 (a) calculating unigram counts in a particular search session;
6 (b) updating unigram frequencies;
7 (c) updating bigram frequencies; and
8 (d) updating each respective semantic correlation between each of the
9 images based on results of (a) through (c).

1 28. A computer-readable medium as recited in claim 15, wherein each
2 respective bigram frequency is based on a pair of unigram frequencies, wherein
3 $C(I)$ is a unigram count of image I , wherein $U(I)$ is a unigram frequency of
4 image I , wherein $B(I,J)$ is a bigram frequency of image I and J , wherein a session
5 group comprises a single search session, and wherein the computer-executable
6 instructions further comprise instructions for performing the respective semantic
7 correlation online by:

8 (a) responsive to determining that there is a user log, updating calculating
9 each respective unigram and bigram frequency according to data in the user log;

10 (b) responsive to determining that there is not a user log, initializing each
11 $C(I)$ and $B(I)$ to zero (0);

12 (c) iteratively updating $C(I)$ for the single search session such that:

13 $C(I) = 1$, if image I is labeled as relevant;

14 $C(I) = -1$, if image I is labeled as irrelevant; and

15 $C(I) = 0$, if $C(I)$ is a non-feedback image;

16 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;

17 (e) updating each respective bigram frequency of an image pair such that:

18 $B(I,J) = B(I,J) + 1$, if $C(I) > 0, C(J) > 0$,

19 $B(I,J) = B(I,J) - 1$, if $C(I) > 0, C(J) < 0$,

20 $B(I,J) = B(I,J) - 1$, if $C(I) < 0, C(J) > 0$, or

21 $B(I,J) = B(I,J)$, otherwise; and

22 wherein I, J are two images, and $B(I, J)$ is their bigram frequency.

1 **29.** A computing device for image retrieval using a statistical bigram
2 correlation model, the computing device comprising:

3 a processor; and

4 a memory coupled to the processor, the memory comprising computer-
5 executable instructions that are fetched and executed by the processor for:

6 receiving a plurality of images responsive to multiple search
7 sessions;

8 determining whether the images are semantically relevant images via
9 relevance feedback; and

10 estimating a respective semantic correlation between each of at least
11 one pair of the images with a respective bigram frequency, each respective bigram
12 frequency being based on multiple search sessions in which each image of the pair
13 is indicated to be a semantically relevant image.

14
15 **30.** A computing device as recited in claim 29, further comprising instructions
16 for:

17 assigning a respective ranking score to each of the images based at least in
18 part on the respective semantic correlation corresponding to the image; and

19 displaying only those images with a highest range of ranking scores.

20
21 **31.** A computing device as recited in claim 29, further comprising instructions
22 for, responsive to a search session, dynamically updating the respective bigram
23 frequency corresponding to two of the images.

1 **32.** A computing device as recited in claim 29, wherein the respective semantic
2 correlation is: (a) a positive correlation between two semantically relevant images;
3 (b) a negative correlation between a semantically relevant image and a
4 semantically irrelevant image; and (c) no correlation otherwise.

5

6 **33.** A computing device as recited in claim 29:

7 wherein the respective semantic correlation is performed offline or online
8 to calculate unigram and bigram frequencies from relevance feedback information,
9 the unigram frequency being based on relevance feedback to a session of the
10 multiple search sessions, the unigram frequency indicating that each respective
11 image of the images is either semantically relevant to the session, semantically
12 less relevant to the session, or a non-feedback image with respect to the session;
13 and

14 wherein each respective bigram frequency is based on a pair of unigram
15 frequencies.

16

17 **34.** A computing device as recited in claim 29, wherein estimating the
18 respective semantic correlation further comprises instructions for:

19 associating a respective unigram frequency with each of the images, the
20 unigram frequency indicating that each respective image of the images is either
21 semantically relevant, semantically less relevant, or a non-feedback image, the
22 unigram frequency being based on relevance feedback to a session of the multiple
23 search sessions; and

24 wherein each respective bigram frequency is based on a pair of unigram
25 frequencies.

1
2 **35.** A computing device as recited in claim 29, wherein estimating the
3 respective semantic correlation further comprises instructions for:

4 associating a respective unigram frequency with each of the images, the
5 unigram frequency indicating that each respective image of the images is either
6 semantically relevant, semantically less relevant, or a non-feedback image, the
7 unigram frequency being based on relevance feedback to a session of the multiple
8 search sessions;

9 determining a maximum frequency from a maximum value of the bigram
10 and unigram frequencies; and

11 wherein the respective semantic correlation is further based on the
12 maximum frequency.

13
14 **36.** A computing device as recited in claim 29, further comprising instructions
15 for identifying, for each image obtained responsive to one or more search sessions
16 of the multiple search sessions, a respective semantic support based on a similarity
17 measure and/or the respective semantic correlation, the similarity measure
18 corresponding to a similarity of a respective feature vector of the image and a
19 search query corresponding to the session.

1 **37.** A computing device as recited in claim 29, further comprising instructions
2 for:

3 identifying, for each image obtained responsive to one or more search
4 sessions of the multiple search sessions, a respective semantic support based on a
5 similarity measure and/or the respective semantic correlation, the similarity
6 measure corresponding to a similarity of a respective feature vector of the image
7 and a search query corresponding to the session;

8 assigning a respective ranking score to each of the images based upon the
9 respective similarity measure, the respective semantic support, and a semantic
10 weight; and

11 displaying only those images with a highest range of respective ranking
12 scores.

13
14 **38.** A computing device as recited in claim 29, wherein estimating the
15 respective semantic correlation is determined as follows:

- 16 • $0 \leq R(I, J) \leq 1$
- 17 • $R(I, J) = R(J, I)$;
- 18 • if $I=J$ and $U(I) \leq 0$: $R(I, J) = 0$;
- 19 • if $I \neq J$ and $B(I, J) \leq 0$: $R(I, J) = 0$;
- 20 • if $I=J$ and $U(I) > 0$: $R(I, J) = U(I)/T$; or
- 21 • if $I \neq J$ and $B(I, J) > 0$: $R(I, J) = B(I)/T$;

22 wherein I, J are two images, $B(I, J)$ is their bigram frequency, $U(I)$ is the
23 unigram frequency of image I , T is the maximum frequency, $R(I, J)$ is the
24 correlation between image I and J.

1 **39.** A computing device as recited in claim 29, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, and wherein the computer-
3 executable instructions further comprise instructions for performing the respective
4 semantic correlation offline by:

- 5 (a) initializing all unigram and bigram frequencies to zero;
6 (b) clustering search sessions with a same query into groups;
7 (c) calculating unigram counts within a group;
8 (d) updating unigram frequencies ;
9 (e) updating bigram frequencies;
10 (f) repeating operations (c), (d), and (f) for all session groups;
11 (g) setting all negative unigram and bigram frequencies to zero; and
12 (h) calculating each respective semantic correlation based on results of (a)
13 through (f).

16044144 MSI-880US PAT APP DOC

1 **40.** A computing device as recited in claim 29, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, wherein $C(I)$ is a unigram
3 count of image I , and wherein the computer-executable instructions further
4 comprise instructions for performing the respective semantic correlation offline
5 by:

6 (a) initializing $C(I)$ to zero (0);

7 (b) iteratively updating $C(I)$ for every session in a group such that:

8 $C(I) = C(I) + 1$, if image I is labeled as relevant in a session;

9 $C(I) = C(I) - 1$, if image I is labeled as irrelevant in a session; and

10 $C(I)$ is unchanged otherwise;

11 (c) repeating (b) for every image of the images;

12 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;

13 (e) updating each respective bigram frequency of an image pair such that:

14 $B(I,J) = B(I,J) + \min\{C(I),C(J)\}$, if $C(I) > 0, C(J) > 0$,

15 $B(I,J) = B(I,J) - \min\{C(I),-C(J)\}$, if $C(I) > 0, C(J) < 0$,

16 $B(I,J) = B(I,J) - \min\{-C(I),C(J)\}$, if $C(I) < 0, C(J) > 0$, and

17 $B(I,J) = B(I,J)$, otherwise; and

18 wherein I, J are two images, $B(I,J)$ is their bigram frequency, and

19 $U(I)$ is the unigram frequency of image I .

1 **41.** A computing device as recited in claim 29, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, and wherein the computer-
3 executable instructions further comprise instructions for performing the respective
4 semantic correlation online by:

- 5 (a) calculating unigram counts in a particular search session;
6 (b) updating unigram frequencies;
7 (c) updating bigram frequencies; and
8 (d) updating each respective semantic correlation between each of the

9 images based on results of (a) through (c).

100-21444-002

1 **42.** A computing device as recited in claim 29, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, wherein $C(I)$ is a unigram
3 count of image I , wherein $U(I)$ is a unigram frequency of image I , wherein
4 $B(I,J)$ is a bigram frequency of image I and J , wherein a session group comprises
5 a single search session, and wherein the computer-executable instructions further
6 comprise instructions for performing the respective semantic correlation online by:

7 (a) responsive to determining that there is a user log, updating calculating
8 each respective unigram and bigram frequency according to data in the user log;

9 (b) responsive to determining that there is not a user log, initializing each
10 $C(I)$ and $B(I)$ to zero (0);

11 (c) iteratively updating $C(I)$ for the single search session such that:

12 $C(I) = 1$, if image I is labeled as relevant;

13 $C(I) = -1$, if image I is labeled as irrelevant; and

14 $C(I) = 0$, if $C(I)$ is a non-feedback image;

15 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;

16 (e) updating each respective bigram frequency of an image pair such that:

17 $B(I,J) = B(I,J) + 1$, if $C(I) > 0, C(J) > 0$,

18 $B(I,J) = B(I,J) - 1$, if $C(I) > 0, C(J) < 0$,

19 $B(I,J) = B(I,J) - 1$, if $C(I) < 0, C(J) > 0$, or

20 $B(I,J) = B(I,J)$, otherwise; and

21 wherein I, J are two images, and $B(I,J)$ is their bigram frequency.

1 **43.** A computing device image retrieval using a statistical bigram correlation
2 model, the computing device comprising:

3 processing means for:

4 receiving a plurality of images responsive to multiple search
5 sessions;

6 determining whether the images are semantically relevant images via
7 relevance feedback; and

8 estimating a respective semantic correlation between each of at least
9 one pair of the images with a respective bigram frequency, each respective bigram
10 frequency being based on multiple search sessions in which each image of the pair
11 is indicated to be a semantically relevant image.

12

13 **44.** A computing device as recited in claim 43, further comprising means for:

14 assigning a respective ranking score to each of the images based at least in
15 part on the respective semantic correlation corresponding to the image; and

16 displaying only those images with a highest range of ranking scores.

17

18 **45.** A computing device as recited in claim 43, further comprising means for,
19 responsive to a search session, dynamically updating the respective bigram
20 frequency corresponding to two of the images.

1 **46.** A computing device as recited in claim 43, wherein the respective semantic
2 correlation is: (a) a positive correlation between two semantically relevant images;
3 (b) a negative correlation between a semantically relevant image and a
4 semantically irrelevant image; and (c) no correlation otherwise.

5

6 **47.** A computing device as recited in claim 43:

7 wherein the respective semantic correlation is performed offline or online
8 to calculate unigram and bigram frequencies from relevance feedback information,
9 the unigram frequency being based on relevance feedback to a session of the
10 multiple search sessions, the unigram frequency indicating that each respective
11 image of the images is either semantically relevant to the session, semantically
12 less relevant to the session, or a non-feedback image with respect to the session;
13 and

14 wherein each respective bigram frequency is based on a pair of unigram
15 frequencies.

16

17 **48.** A computing device as recited in claim 43, wherein the processing means
18 for estimating the respective semantic correlation further comprises means for:

19 associating a respective unigram frequency with each of the images, the
20 unigram frequency indicating that each respective image of the images is either
21 semantically relevant, semantically less relevant, or a non-feedback image, the
22 unigram frequency being based on relevance feedback to a session of the multiple
23 search sessions; and

24 wherein each respective bigram frequency is based on a pair of unigram
25 frequencies.

1
2 **49.** A computing device as recited in claim 43, wherein the processing means
3 for estimating the respective semantic correlation further comprises means for:

4 associating a respective unigram frequency with each of the images, the
5 unigram frequency indicating that each respective image of the images is either
6 semantically relevant, semantically less relevant, or a non-feedback image, the
7 unigram frequency being based on relevance feedback to a session of the multiple
8 search sessions;

9 determining a maximum frequency from a maximum value of the bigram
10 and unigram frequencies; and

11 wherein the respective semantic correlation is further based on the
12 maximum frequency.

13
14 **50.** A computing device as recited in claim 43, further comprising processing
15 means for identifying, for each image obtained responsive to one or more search
16 sessions of the multiple search sessions, a respective semantic support based on a
17 similarity measure and/or the respective semantic correlation, the similarity
18 measure corresponding to a similarity of a respective feature vector of the image
19 and a search query corresponding to the session.

1 **51.** A computing device as recited in claim 43, further comprising processing
2 means for:

3 identifying, for each image obtained responsive to one or more search
4 sessions of the multiple search sessions, a respective semantic support based on a
5 similarity measure and/or the respective semantic correlation, the similarity
6 measure corresponding to a similarity of a respective feature vector of the image
7 and a search query corresponding to the session;

8 assigning a respective ranking score to each of the images based upon the
9 respective similarity measure, the respective semantic support, and a semantic
10 weight; and

11 displaying only those images with a highest range of respective ranking
12 scores.

13
14 **52.** A computing device as recited in claim 43, wherein the processing means
15 for estimating the respective semantic correlation is determined as follows:

- 16 • $0 \leq R(I, J) \leq 1 :$
- 17 • $R(I, J) = R(J, I) ;$
- 18 • if $I = J$ and $U(I) \leq 0 : R(I, J) = 0 ;$
- 19 • if $I \neq J$ and $B(I, J) \leq 0 : R(I, J) = 0 ;$
- 20 • if $I = J$ and $U(I) > 0 : R(I, J) = U(I)/T ;$ or
- 21 • if $I \neq J$ and $B(I, J) > 0 : R(I, J) = B(I)/T ;$

22 wherein I, J are two images, $B(I, J)$ is their bigram frequency, $U(I)$ is the
23 unigram frequency of image I, T is the maximum frequency, $R(I, J)$ is the
24 correlation between image I and J.

1 **53.** A computing device as recited in claim 43, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, and wherein the processing
3 means further comprise means for performing the respective semantic correlation
4 offline by:

- 5 (a) initializing all unigram and bigram frequencies to zero;
6 (b) clustering search sessions with a same query into groups;
7 (c) calculating unigram counts within a group;
8 (d) updating unigram frequencies ;
9 (e) updating bigram frequencies;
10 (f) repeating operations (c), (d), and (f) for all session groups;
11 (g) setting all negative unigram and bigram frequencies to zero; and
12 (h) calculating each respective semantic correlation based on results of (a)
13 through (f).

P000014200144
P000014200145
P000014200146
P000014200147

1 **54.** A computing device as recited in claim 43, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, wherein $C(I)$ is a unigram
3 count of image I , and wherein the processing means further comprise means for
4 performing the respective semantic correlation offline by:

5 (a) initializing $C(I)$ to zero (0);

6 (b) iteratively updating $C(I)$ for every session in a group such that:

7 $C(I) = C(I) + 1$, if image I is labeled as relevant in a session;

8 $C(I) = C(I) - 1$, if image I is labeled as irrelevant in a session; and

9 $C(I)$ is unchanged otherwise;

10 (c) repeating (b) for every image of the images;

11 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;

12 (e) updating each respective bigram frequency of an image pair such that:

13 $B(I,J) = B(I,J) + \min\{C(I),C(J)\}$, if $C(I) > 0, C(J) > 0$,

14 $B(I,J) = B(I,J) - \min\{C(I),-C(J)\}$, if $C(I) > 0, C(J) < 0$,

15 $B(I,J) = B(I,J) - \min\{-C(I),C(J)\}$, if $C(I) < 0, C(J) > 0$, and

16 $B(I,J) = B(I,J)$, otherwise; and

17 wherein I, J are two images, $B(I,J)$ is their bigram frequency, and

18 $U(I)$ is the unigram frequency of image I .

1 **55.** A computing device as recited in claim 43, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, and wherein the processing
3 means further comprise means for performing the respective semantic correlation
4 online by:

- 5 (a) calculating unigram counts in a particular search session;
6 (b) updating unigram frequencies;
7 (c) updating bigram frequencies; and
8 (d) updating each respective semantic correlation between each of the
9 images based on results of (a) through (c).

1 **56.** A computing device as recited in claim 43, wherein each respective bigram
2 frequency is based on a pair of unigram frequencies, wherein $C(I)$ is a unigram
3 count of image I , wherein $U(I)$ is a unigram frequency of image I , wherein
4 $B(I,J)$ is a bigram frequency of image I and J , wherein a session group comprises
5 a single search session, and wherein the processing means further comprise means
6 for performing the respective semantic correlation online by:

- 7 (a) responsive to determining that there is a user log, updating calculating
8 each respective unigram and bigram frequency according to data in the user log;
- 9 (b) responsive to determining that there is not a user log, initializing each
10 $C(I)$ and $B(I)$ to zero (0);
- 11 (c) iteratively updating $C(I)$ for the single search session such that:
12 $C(I) = 1$, if image I is labeled as relevant;
13 $C(I) = -1$, if image I is labeled as irrelevant; and
14 $C(I) = 0$, if $C(I)$ is a non-feedback image;
15 (d) updating each respective unigram frequencies as $U(I) = U(I) + C(I)$;
16 (e) updating each respective bigram frequency of an image pair such that:
17 $B(I,J) = B(I,J) + 1$, if $C(I) > 0, C(J) > 0$,
18 $B(I,J) = B(I,J) - 1$, if $C(I) > 0, C(J) < 0$,
19 $B(I,J) = B(I,J) - 1$, if $C(I) < 0, C(J) > 0$, or
20 $B(I,J) = B(I,J)$, otherwise; and
21 wherein I, J are two images, and $B(I, J)$ is their bigram frequency.